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(54) Active matrix substrate

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SPECIFICATION

TITLE OF THE INVENTION

Active matrix substrate

SCOPE OF CLAIM

An active matrix substrate characterized in that, in an active matrix IC substrate in which a matrix is formed from a data line and a gate line, a peripheral driver circuit including each shift register column for driving the data line and the gate line is incorporated, and further the peripheral driver circuit is arranged in a substrate circumference portion surrounding a matrix circuit, the peripheral driver circuit and all transistors to be configured or a portion of them are formed from transistors with a high mobility as compared with the matrix circuit.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an active matrix substrate using at least a polycrystalline silicon or an amorphous silicon as a main component material on a transparent substrate such as a soda glass, a borosilicate glass or a quartz glass.

In recent years, an application field of a flat plate type liquid crystal display is being enlarged to cars, measuring equipment, information device terminals, in addition to watches, calculators and toys. Recently, in particular, a liquid crystal display panel for displaying a television image in which a switching transistor circuit is formed on a Si substrate in matrix form by a semiconductor integrated circuit technology, and a liquid crystal is encapsulated between the Si substrate and a transparent glass substrate has been developed.

Examples of forming a liquid crystal panel with an active matrix system have been already reported, such as one using the single crystal Si substrate, one in which a thin film transistor is formed on a glass substrate, one using a varistor substrate, and the like. Among them, an active matrix substrate in which a thin film transistor is formed on the glass substrate is considered to be a promising system in terms of making a larger panel and a cost.

Conventionally, it is publicly known that a low-temperature process should be employed for a thin film transistor formed by depositing a polycrystalline silicon or the like on a glass substrate in terms of heat-limitation on a substrate. However, in the case of an active matrix substrate using the thin film transistor, a peripheral driver circuit requires a high-frequency operation and thus, the mobility must be close to that

of a single crystal silicon, setting aside an active matrix circuit. Therefore, it is typical that a peripheral driver circuit is formed on a single crystal silicon substrate and attached externally to an active matrix substrate.

However, it is needless to say that the conventional method leads to drastically increasing costs when including costs for attaching externally to an active matrix substrate, in addition to manufacturing costs of a peripheral driver circuit substrate.

Also, in the case where an active matrix substrate is formed by using a heat-resistance material such as a quartz substrate as a substrate material, a high-temperature process of 1000 °C or higher is possible; therefore it is possible to manufacture an active matrix substrate incorporating a peripheral driver circuit.

However, there is a problem of light-leakage here.

Normally, it is natural that a flat plate liquid crystal display is frequently used under sunlight, since it is vital use as a portable and outdoor one.

As for an active matrix IC substrate, light enters also an IC substrate since a display screen is directly subjected to sunlight. The incident light of the IC substrate generates an electron and a hole. And when they diffuse into the substrate and reach a P-N junction portion, a current flows through the P-N junction portion. In other words, this photovoltaic effect causes a leak phenomenon in the P-N junction portion of a source and a drain of a transistor; therefore an accurate image display is not obtained and the image flickers or disappears. Therefore, there is a reduction of a leak current by decreasing a mobility of a substrate as a means for suppressing the light leak phenomenon. As mentioned above, that is possible to some extent in an active matrix substrate circuit.

However, the high-temperature process crystallizes a whole polycrystalline silicon on a quartz substrate, and thus, it is natural that the mobility is increased and the leak current is increased, which is not a preferable structure.

Also, recently as is commonly known, a technology of crystallizing by irradiating an amorphous or polycrystalline silicon surface with laser light or EB (electron beam), or a technology for eliminating damages in ion irradiation has been developed.

Above all, there are various methods such as CW argon laser, CW krypton laser, pulsed YAG laser, and CW excited YAG laser for laser heating, and they have fundamental differences in structures or operations from output, energy or a spot diameter to production stability, and selection depending on an object becomes an important element.

When this laser annealing technique is employed using laser light, it is possible

to perform laser annealing on e.g., an active matrix substrate incorporating a peripheral driver circuit on a glass substrate to enhance the mobility fully. However, as the laser annealing effect, a throughout is determined depending on a spot diameter and irradiation time, and thus, when laser annealing is performed on a whole substrate, for example, productivity per an hour is about several substrates and small, which leads to a very inefficient step.

As mentioned above, various shortcomings of the conventional method should be improved for manufacturing a low-cost active matrix substrate that is tolerant to light-leakage.

The present invention eliminates the shortcomings of the conventional method, in other words, an active matrix circuit using a polycrystalline silicon or an amorphous silicon as the main component on a transparent substrate such as glass is formed. Further, a peripheral driver circuit is arranged on the same substrate by incorporating the active matrix substrate, only the peripheral driver circuit region is processed by laser annealing or the like, thereby enhancing the mobility of a transistor. Namely, as mentioned above, the throughput is increased by conducting laser annealing only on a driver circuit in the periphery of a substrate as a means for enhancing the mobility, as well as incorporating a peripheral driver circuit. Further, a characteristic that light-leakage prevention is enhanced by reducing the mobility of an internal active matrix circuit is provided.

Next, the present invention is described in detail based on Embodiments mentioned below.

Embodiment (1)

FIG. 1 shows an active matrix substrate, in which an active matrix circuit 2 is arranged in a center portion and a peripheral driver circuit 3 is arranged in a circumference portion on a borosilicate glass substrate 1, according to the present invention.

FIGS. 2(a) to 2(c) are cross sectional views of a substrate for describing manufacturing steps of an active matrix substrate of the present invention. A first polycrystalline silicon film 4 of 5000 angstroms is formed on the borosilicate glass substrate 1 under a low pressure atmosphere of 625 °C as shown in FIG. 2(a) first, and thereafter, the polycrystalline silicon film 4 is photo-etched to be partially opened. Then, while scanning a beam with a beam diameter of 200 μm, a linear velocity 50 cm/sec as a CW excited YAG laser as a light-source in a horizontal direction on the peripheral portion on the substrate, that is, only inside the region of the peripheral driver circuit 3 of FIG. 1 as shown in FIG. 3(a), a laser annealing process is further conducted

in the orders 1 to 4. Then, a CVD-SiO_2 film 5 of 2000 angstrom is deposited wholly as shown in FIG. 2(b), and then, a second polycrystalline silicon film 6 is formed by the same forming method as the first polycrystalline silicon film; thereafter, the polycrystalline silicon film 6 is photo-etched to open source drain portions.

Then, phosphorous ion of 1×10^{15} /cm^2 is irradiated on the surface of the substrate, annealing is performed in a forming gas of 550 °C 1 H to form a diffusion layer. Next, as shown in FIG. 2(c), a CVD-SiO_2 film 7 is formed, a contact hole is opened, an electrode 8 is sequentially formed to finish the active matrix substrate formation. The line numbers of gate lines and data lines of the active matrix circuit used in the present embodiment are each 200, it is observed that the operations of the data line with about 1 MHz and the gate line with 25 KHz using the substrate and an adequate performance is obtained as a liquid crystal display. In addition, an annealing throughput is enhanced several times or more as compared with the conventional one as the effect of the laser annealing process. Moreover, the motilities of about 10 cm/V-sec in the active matrix driver circuit and about 100 cm/V-sec in the peripheral driver circuit portion can be obtained.

Embodiment (2)

As in Embodiment (1), a first polycrystalline silicon film is formed and then photo-etched to partially be opened, and after that, the regions (1) and (3) of the peripheral driver circuit are processed by laser annealing under the same conditions as Embodiment (1) as shown in FIG. 3(b). Thereafter, (2) and (4) of the peripheral driver circuit are irradiated with low output energy density of about 1 J/cm^2 as compared with (1) and (3). In other words, the whole circuit is not required to be irradiated with the same energy density, since the regions (2) and (4) of the peripheral driver circuit are for driving gate lines and low frequency operation as compared with (1) and (3) for date lines is possible. As the result of this embodiment, it is observed that the mobility enough to operate gate lines is obtained, and further, the throughput 1 in two sides of the substrate circumference portion can be more enhanced as compared with Embodiment because of low energy density irradiation.

Embodiment (3)

As in Embodiment (1), a first polycrystalline silicon film is formed and then photo-etched to partially be opened, and after that, the regions (1) and (3) of the peripheral driver circuit, that is, only data line driver circuit regions are processed by laser annealing under the same conditions as Embodiment (1) as shown in FIG. 3(c).
In other words, as described in Embodiment (2), an active matrix substrate, in particular, in which the line number of gate lines is small, can be dealt adequately by the system,

and the throughput is expected to be increased dramatically.

Embodiment (4)

As in Embodiment (1), a first polycrystalline silicon film is formed and then photo-etched to partially be opened, and after that, laser annealing irradiation is performed on the peripheral driver circuit region of the substrate: the region (1) is processed by scanning a beam in a horizontal direction as shown by the arrow first, and sequentially the region (2) is irradiated in the same manner as (1) while rotating the substrate with 90° to the center, and the regions (3) and (4) are irradiated in the same manner while rotating the substrate as shown in FIG. 3(d). This system can reduce the number of scanning a beam as compared with Embodiment (1), and thus, it has an advantage of enhancing the throughput as compared with embodiment (1).

As mentioned in Embodiments (1) to (4), the present invention makes it possible to make an active matrix circuit and a peripheral driver circuit as one chip on a glass substrate and at the same time, to perform laser annealing irradiation on only the driver circuit by using a laser annealing technique to provide the active matrix circuit with a measure for light-leakage resistance, and to provide the low cost active matrix substrate that is tolerant to light-leakage, in the active matrix substrate used for a flat plate liquid crystal display or the like.

Note that a borosilicate glass substrate is used for the transparent substrate is a quartz substrate may be used. Further, in addition to laser annealing as an enhancing means of the mobility of a transistor, the effect of EB or the like has been confirmed. The irradiation conditions can be selected freely depending on an object, and never departs from the object of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit arrangement view in an active matrix substrate according to the present invention.

FIGS. 2(a) to 2(c) are cross sectional views of a substrate showing manufacturing steps of an active matrix substrate according to the present invention.

FIGS. 3(a) to 3(d) are plane views showing a laser annealing irradiation method to a peripheral driver circuit region on an active matrix substrate according to the present invention.

1...glass substrate

2...active matrix circuit

3...peripheral driver circuit
4...polycrystalline silicon film
5...CVD-SiO_2 film
6...polycrystalline silicon film
7...CVD-SiO_2 film
8...electrode

period.

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